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Influence of Environment and Breeding in Increasing Dairy Production—III

By Earl Weaver, C. A. Matthews and H. H. Kildee

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Summary

1. The use of purebred dairy sires proved an effective means of building up a good grade dairy herd from a foundation of scrub cows.

2. The bulls that were used effected improvement in each generation until the fourth generation was reached.

3. The bulls of each breed varied greatly in their ability to transmit production to their daughters.

4. Of the 14 purebred bulls used in the experiment, three proved valueless—one of them decidedly so; four of them were very valuable while the other seven were of such caliber as would justify their use in reasonably good herds.

5. Daughters sired by a scrub bull showed no greater increase in production over their dams than would be attributed to the improved environment under which these daughters were reared.

6. In the purchase of a sire, the safest index of his transmitting ability is the kind of daughters he has already sired. Other considerations are his health, breeding, type and the price for which he can be secured.

7. The scrubs that were heifers or calves when they reached the station farm produced more abundantly thruout their lives than did those that were mature. This was due to the improved feeding to which they were subjected while young.

8. Those scrubs that were 4 years old when they arrived increased in production each year after their arrival at a more rapid rate than could be explained by the maturing of the animals.

9. The scrubs that were mature when they arrived did not increase in production after the first year.

10. In persistency of production the scrubs ranked the lowest, followed by the first generation grades and then by the second generation grades. The latter compared favorably with the purebreds in this respect. The third generation Holstein grades were the most persistent of all groups while the fourth generation grades fell short in relative persistency.

11. Not only were the grades of the first, second and third generations more abundant producers than their ancestors but they were more economical in their use of feed and they returned greater profits over feed costs. The fourth generation grades fell short of the third generation in these respects.

12. It was observed that between cows of similar or identical breeding there was great variation in producing ability.

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The constant growth of the dairy industry constitutes a notable phase in the history of American agriculture. That the industry will continue to grow is beyond question. The wider knowledge of the food value of dairy products, the increasing demands in America for intensive and economical production, to which demands dairying is especially adapted, and the more general recognition of the financial possibilities that lie in dairy farming all attest the view that the greatest development of the industry is yet to be realized.

Good dairy cows are indisputably the foundation upon which this development will depend and what is just as true, such development will be accompanied by a steadily increasing demand for these good cows.

Conditions in America are such that for many years only a small percentage of the dairy products will be secured from purebred cows. Only about 3 percent of the dairy cattle of the United States are purebred. In Iowa an even smaller percentage of the dairy cattle are purebreds. The great majority are grades and scrubs.

Reliable information from many sources indicates that a large proportion of the cows in the United States are inferior and unprofitable. No doubt some of these inferior cows are purebreds, of course some of them are grades but certainly in their ranks are found nearly all the scrub cows of the country. These scrub cows are a handicap to the progress of the dairy industry.

Farmers generally are coming to recognize the limitations which inferior cows impose upon their owners and of the economic advantages which owners of good cows enjoy.

Consequently, many farmers who have only mediocre cows are seeking some means whereby they can effect improvement in their herds. Two alternatives present themselves to these men. They can sell their common cows and buy good ones. This is an expedient manner of establishing a herd and it gets quick results. However, it entails considerable expense because good cows are in great demand and so are costly. Also this scheme entails some hazard because in making purchases there is always the danger from diseases which any purchased cow may introduce into a herd and which may make serious encroachment. A further difficulty is that of selecting cred-

itable cows. There is always the likelihood that some cows which are purchased will prove to be unproductive and unprofitable.

The second alternative for a farmer who desires to have better dairy cows is to mate his common cows with good purebred dairy bulls and thereby build a herd of creditable producers. Objections to this plan are that it is slow and laborious. Three or four years must elapse before any results of this plan manifest themselves. Furthermore, there is always the possibility that a bull, even tho he be a purebred, may not effect the improvement in his daughters over their dams that might be desired.

However, the use of purebred sires to build up a grade herd from common cows is not an expensive procedure and it involves no extra hazard from communicable diseases. Economically, it is a safe and sound procedure.

The experiment which is reported here was carried on with a primary view of determining the possibilities in breeding up a good grade herd thru the use of purebred dairy sires on scrub cows.

The results of the work lend the greatest encouragement to the practice. When good purebred bulls were mated to scrub and grade cows, the offspring showed remarkable increases over their dams in productivity and profit.

Previous Work

From many sources there is evidence bearing upon the value of purebred bulls in increasing production in dairy herds. Some of this work has had to do with herds of purebred females and some with grades.

In 1916, Kildee and McCandlish (4) made a preliminary report on the results that had been secured up to that time in the experiment recorded here. This first report dealt largely with the production increases that were shown by the first generation grades which resulted from the use of purebred dairy sires on scrub cows. Again in 1919, McCandlish, Gillette and Kildee (7) made a further report of the results which up to that time included production records on both first and second generation grades. The daughters of the scrub cows produced 64 percent more milk and 52 percent more fat than did the scrubs, while the granddaughters showed average increases of 130 percent in milk and 109 percent in fat.

Tho the influence of improved breeding played the conspicuous part in both these reports, the beneficial effects of better feeding were likewise recorded.

An experiment very similiar to the work at this station has been reported from South Dakota by Olson and Biggar (9).

These authors found that purebred Holstein, Jersey and Guernsey bulls mated to grade beef cows effected increases in the first generation of 61 percent in milk and 52 percent in fat. In the second generation the milk yield was even lower than that of the first generation but the fat yield was somewhat higher. The fat yield for the second generation grades was 57 percent higher than that of the granddams.

Recently an extensive study relating to the value of dairy bulls has been inaugurated by the Bureau of Dairying of the United States Department of Agriculture. In this study McDowell and Parker (8) secured from various cow testing associations in the United States records on 1,016 grade cows sired by purebred dairy bulls. The records of these cows reveal the influence which purebred bulls exert upon the productivity of grade herds.

These authors were particularly concerned in recording the variability of different bulls in effecting increased production in their daughters. The authors say, ". . . in general, the tabulations showed that most purebred sires will increase the production of the daughters above that of low producing dams. However, as the production of the dams increases, better and still better sires must be used or the daughters will not excel the production records of the dams."

The above references deal with the influence of purebred sires when mated to scrub and grade cows. Other workers have reported upon the value of purebred sires in purebred herds. Among these is Eckles (2) who assembled data on six Jersey bulls used in the Missouri station herd. He was one of the first men to direct attention to the fact that bulls vary materially in their ability to transmit production. The daughters of the best one of these Jersey bulls produced 68 percent more milk and 61 percent more fat than did their dams.

The fact that one of the bulls actually proved detrimental is an unfortunate commentary upon the situation that exists in many herds in the country, but such a possibility must be recognized in any breeding study. This phase of the question will be considered later.

Olson and Gilcreast (10) reported the records of purebred and grade daughters of Holstein and Jersey bulls used in the South Dakota station herd. Like other workers, these men found that some of the bulls had proved of enormous value while some of them were useless. They called attention to the estimated monetary value of one of the bulls that was used. On a basis of the calculations that they made, which calculations dealt entirely with the market value of the increased butterfat yielded by this bull's daughters and ignored

the higher valuation on his offspring, he would have been worth $702.30 a year in a herd of 20 cows. This is a conservative estimate. The performance of this bull was not phenomenal, yet with such bulls in dairy herds the possibility for increased profits is enormous.

At Indiana, Fairchild (3) presented data relative to the purebred Jerseys and Holsteins in the station herd. The daughters of all the bulls produced more than their dams. The 21 daughters of three Jersey bulls produced 33 percent more milk and 32-percent more fat than their dams. The 16 daughters of four Holstein bulls produced 23 percent more milk and 29 percent more fat than their dams.

Reference has been made to the study of McDowell and Parker (8) with grade cows. Purebred cows were also involved in the same study and the authors revealed the existence of the same situation as to the value of purebred bulls upon purebred cows as they reported with grade cows.

A further trial bearing upon this general question of grading-up a herd is reported by Cunningham (1). His work was with goats. He secured scrub does and bred them to purebred Toggenburg bucks. In the first generation that resulted from these matings there were 19 does. These does produced 77 percent more milk than the scrub dams. In the second generation the increase was 81 percent in milk over the scrub granddams.

The Objects of This Experiment

The objects of the experiment reported in this bulletin were as follows:

1. To determine the effectiveness of purebred dairy bulls in building a creditable grade herd from a foundation of scrub cows.
2. To obtain evidence as to how far such grading-up might be continued before reaching a point in improvement beyond which further increases in production would not be easily secured.
3. To note the variation in transmitting ability of different purebred bulls of the same breed.
4. To study the records of heifers sired by a scrub bull in comparison with the records of the dams of these heifers.
5. To note the variation in production among individual cows of the same or similar breeding.
6. To assemble some data as to the factors which are of greatest importance in selecting sires for dairy herds.
7. To determine the effects of improved feeding practice upon milk yields.
8. To determine the relative feed costs and the efficiency

and economy of production of the scrubs and of the grades in the different generations.

Animals Used

The foundation animals used in this work were purchased in an isolated region in Arkansas. It was desired to secure animals that possessed no blood of an improved dairy breed and this region offered greater facility in this respect than did any section of Iowa, where it was felt that at least some more attention had probably been devoted to improving the native cattle. Available records revealed that no purebred bulls had been used in that region of Arkansas.

An objective in selecting the animals was that they be decidedly inferior in order that such production records as might be obtained on their descendants would not be an exaggeration of what farmers could expect from the use of purebred dairy sires on their common cows. That eminent success was experienced in securing cows of the desired degree of inferiority is apparent upon referring to the photographs of some of the scrub cows that appear on later pages.

The animals were small and under-developed. They were shallow and narrow, thus lacking in capacity, and they were very deficient in dairy character and mammary development. Their udders were small and misshapen. The hair coats and hides were harsh and gave evidence of a lack of thrift and vigor. These defects were accentuated by characteristic drooping rumps and weak top-lines. The cows were extremely nervous and in some cases vicious.

The environment under which these cattle had been kept was not conducive to abundant production. Feeding had been largely neglected, very little, if any, concentrates having been used. The cattle had been forced to subsist largely upon the scanty supply of grass and hay available. No attention had been paid to the amount nor quality of milk produced by these animals nor to the length of lactation periods.

The foundation animals consisted of five mature cows, two four-year-olds, four yearling heifers, two heifer calves and a young scrub bull. At the time of the purchase some of the cows were in calf to a scrub bull. Subsequent to their arrival, one of them dropped a heifer calf from this mating and this calf was used in the experiment. Two of the cows dropped bull calves from this mating, which bull calves were used along with two scrub heifer calves in a digestion trial. These two bulls were not involved otherwise and it has been the practice to kill the grade bulls at birth or to sell them for veal.

Thirteen head of females were purchased and the one scrub heifer calf dropped after their arrival makes a total of 14 scrub females upon which production records have been secured. Data regarding these animals are given in table I.

TABLE I. THE SCRUB FEMALES.

Herd No.	Age on Arrival
6	4 years
7	mature
8	mature
9	mature
12	mature
31	4 years
33	mature
52	yearling
53	yearling
54	yearling
56	yearling
58	calf
59	calf
60	in dam

Some of the scrub cows dropped only bull calves during their entire time in the herd. Thus the number of grade heifers for use in this work is not so great as might be desired.

Purebred sires of the Ayrshire, Guernsey, Holstein and Jersey breeds were used on these scrub cows. When the cows were first secured no Ayrshire bull was available for the matings because Ayrshires had not yet been established in the station herd. Then after an Ayrshire bull had been obtained, all the matings of him with scrub cows resulted in bull calves, thus no Ayrshires are involved in this work.

TABLE II. THE SIRES AND THEIR DAUGHTERS.

Letter designation of sire	Generation mated with	Herd numbers of daughters
	Guernseys	
A	Scrubs	87, 110
B	Scrubs	175, 180, 253, 288, 308
B	First	236, 296, 448
C	First	298, 301
D	First	343, 356, 391
E	First	460, 496
	Holsteins	
F	Scrubs	68, 69, 77, 207
G	First	233
H	First	281, 282, 311, 323, 373
I	First	463
I	Second	399, 485, 504
J	Second	577
J	Third	578, 587, 634
	Jerseys	
K	Scrubs	174, 213, 241
L	First	245
M	First	348
N	First	398

There have been used five Guernsey bulls, five Holstein bulls and four Jersey bulls, the daughters of which have completed records. Table II indicates the daughters sired by each of these bulls.

No particular plan was involved in determining which of the scrub cows were to be bred to bulls of a certain breed. Some of them were bred to bulls of more than one breed and thus have first generation grade daughters of more than one breed.

With the results that were secured on the first and second generation grades of the three breeds it was felt that sufficient data had been assembled to establish the value of pure-bred sires of all these breeds in grading-up a herd from common stock. However, it was desired to continue the matings to a further point with at least one of the breeds so that the second object of the experiment might be realized. This object was to determine how far the grading-up might be continued before a point was reached beyond which further increases would not be easily secured.

It was felt that any results which might be secured with one breed would be equally applicable to the others. At that particular time there were more of the Holstein grades available and the matings were continued with this breed only.

Attention is called to the fact that at no time was any cross-breeding practiced in this experiment. A grade daughter of a bull of a certain breed was always bred to other bulls of the same breed.

Furthermore, except in two cases, inbreeding was not employed. In one of these cases a third generation Holstein grade by sire I was bred back to her sire but the resultant calf was born blind and was immediately destroyed. In the other case the result was satisfactory.

In any dairy herd a shortage of available money with which to buy a bull and an inability to locate an entirely satisfactory one frequently constitute a temptation to breed heifers back to their sire. In this experiment station herd such difficulties are multiplied four-fold because four separate breeds are maintained but in all cases, except the two mentioned above, a solution to the difficulties was found without serious interruptions of the plans and without resorting to inbreeding.

A further fact to be noted in regard to the animals used in this trial is that no culling-out of low producers was practiced. In a very few cases when cows were decidedly abnormal because of any diseased condition or when cows died within a few months after freshening, the record for that lactation was omitted. However, no cow was sold because of inferiority.

It is recognized that at the outset culling could have been employed in a premeditated scheme so that the average production records on later generations would show enormous increases. Such a plan, however, would have served only to inject a factor other than improved breeding into the data and would have led to an exaggeration in the results. As the data now stand they represent the sum total of the influence of the purebred sires upon the production of their daughters. There is another very important fact to be considered in this connection. The production increases to be reported later for the grade cows are considerable. However, any dairyman who will test his cows can eliminate the low producers from his herd and thereby secure even greater improvement than was secured in the experiment where no selection was practiced.

The Care of the Animals

At all times a rational system of feeding the cows of this experiment has been followed. It has been the usual practice to furnish them with legume hay and corn silage during winter seasons. During summers they had access to fairly good bluegrass pasture. In periods of short pastures the cows were also fed silage or soiling crops. With few exceptions they were fed all the roughages they would eat without waste. The amounts of concentrates fed were determined by the daily milk yield and the condition of the cow. This was true not only for the higher producing grades but also for the scrubs.

In so far as legume hays were generally available, only small proportions of high protein feeds were used in the concentrate mixtures. The chief portions of these mixtures consisted of corn and oats.

In a general way it would be said that the cows were well fed, but they were not forced to maximum production.

The cows of the experiment were housed along with the purebreds in the college herd. They were subjected to the same management methods. At times they were used in various feeding trials which were in progress and some of these trials were quite drastic in nature and detrimental to the production of the cows. The cows were also used for the judging work of the students, often spending from two to six hours daily in these judging rings. While the cows presumably became quite accustomed to such treatment, there is no doubt that their production was impaired thereby.

The heifer calves were so fed as to permit of good vigorous growth. As yearlings they were furnished liberal quantities of legume hay and corn silage. As these heifers approached

their first freshening they were generally given some concentrates to put them in good condition.

The Collection of Data

Complete data regarding birth dates and weights, and service and freshening dates have been obtained on all the grades in the experiment. There were no previous records for the scrubs that were purchased. Their ages were determined by examination of their teeth.

At an early period in the experiment the plan of weighing the cows at regular intervals was adopted. This plan has been continued to the present time. The milk from each cow has been weighed at each milking and a sample taken for a weekly composite. From these weekly composites the butterfat tests have been determined.

The concentrate allowance for each cow has been weighed daily, but the amounts of roughages eaten have been estimated from occasional weighings. All these records have been secured while the cows were dry as well as while they were in milk.

In this work a year record period is for 360 days or for less if a cow continued in milk for a shorter number of days. As has been stated all records even for very short periods are included unless sickness, disease or an accident occurred and materially reduced the milk flow or unless a cow died very early in lactation.

Furthermore, in all the tables that follow a record on a cow is her average record for her entire lifetime. No selected, single, high record is picked out as is often done in describing a cow's production. If only the highest record on each cow of later generations had been used the increases would have appeared enormous but the application of the data would have been decidedly limited. This method of handling the data must be recognized in placing an interpretation upon the results.

To permit of direct comparisons, the records are all given on a mature basis. In computing these to a mature basis, the percentages as given in table III were used.

TABLE III. PERCENTAGES USED FOR COMPUTING HEIFER RECORDS TO A MATURE BASIS.

Age of cow at start of record	Percentage of a mature record
Yearlings	70
Two-year-olds	80
Three-year-olds	85
Four-year-olds	95

These percentages are suggested by McCandlish (5) from a study of over 10,000 yearly records in the Jersey Register of Merit and the Guernsey Advanced Register.

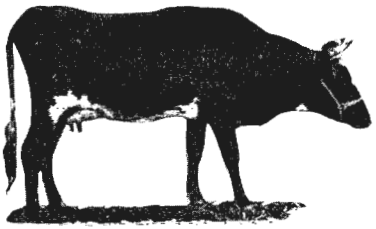

Fig. 1. Scrub No. 6, showing condition on arrival. First year's record at station—131 pounds of fat.

It is to be noted here that the production records used in computing the feed requirements, costs and returns per 100 pounds of milk, as appear in tables XIV and XV, and in determining persistencies, as appear in figs. 25 and 26, are actual records and are not converted to a mature basis.

Discussion of Results

The objects of this experiment, as indicated previously, were numerous, thus involving different phases of the work. While these various phases all bear a relationship to the general problem, they are sufficiently distinct to necessitate a separate discussion of the effects that are attributed to each one of them.

Even tho the influence of environment was not a primary object of the work, the results upon this phase of the question are presented first because the effects of improved feeding were recognized with the scrub foundation cows before any other results could be detected. Furthermore, it easily lies within the province of a great many farmers to improve their feeding methods and almost immediately secure some benefit thru increased production economy.

THE INFLUENCE OF BETTER FEEDING

It was unfortunate in this work that the production records made by the scrub cows while they were yet in Arkansas were not available. Had it been possible to secure such records a direct comparison between them and the records made by the cows after their arrival at the station would have been of great value. As it is, a very satisfactory indication of the influence of better feeding may be found in comparing the records of the cows the first year after they reached the station with their records in later years. One such comparison is furnished in figs. 1 and 2.

Figure 1 shows the four-year-old scrub cow no. 6 as she appeared upon arrival at the farm. Figure 2 shows the same cow three years later. The improvement in appearance, health

and vigor of this cow after three years of adequate feeding is apparent. Also her increased productivity is noteworthy.

Table IV shows the records of the scrub cows during successive lactations after they arrived at the station. The cows are grouped according to their ages when they arrived and the records are not converted to a mature basis.

Fig. 2. Scrub No. 6, three years later. Record—245 pounds of fat. Increase over first record—87 percent.

For those animals that were received as mature cows, table IV does not show increases after the first year. The inference is justified that these cows had reached the point where advancing age brought a decline in productivity after the first year which good care and feeding could not prevent.

Those cows that were 4 years old on arrival displayed remarkable increases in production after their first year's records

TABLE IV. RECORDS OF SCRUB COWS DURING SUCCESSIVE LACTATIONS AFTER ARRIVAL AT THE STATION

Lactation No.	No. of cows	Age years	Average production		Increase over first lactation	
			Milk pounds	Fat pounds	Milk percent	Fat percent
Cows Received as Mature Cows						
1	5	Mature	3791	184		
2	5	Mature	2874	135	—24	—27
3	5	Mature	2841	142	—25	—23
Cows Received as Four-Year-Olds						
1	2	4	3085	149		
2	2	5	3984	179	29	20
3	2	6	4618	218	50	46
4	2	7	4908	230	59	54
5	2	8	4224	198	37	33
6	2	9	1991	85	—35	—43
7	2	10	2862	134	— 7	—10
8	1	11	2296	95	—26	—36
Cows Received as Yearlings and Calves						
1	3	2	2745	143		
2	6	3	4175	199	52	39
3	5	4	3481	171	27	20
4	4	5	3269	157	19	10
5	3	6	3874	176	41	23
6	3	7	4443	201	62	41
7	2	8	5634	252	105	76
8	2	9	2813	123	2	—14

were made. During their second year they produced 29 percent more milk and 20 percent more fat than during their first year. These increases continued until their fourth yearly records when they were 7 years old. At this age they produced 59 percent more milk and 54 percent more fat than in their first year. The increases that would be expected because of the maturing of the cows are only 10 percent in milk and 8 percent in fat as was found by McCandlish (5). Admittedly the improved feeding had considerable influence on the first records made by these cows, but the accumulative effects of such feeding were very pronounced in the third and fourth years. After the cows passed the age of 7 years the decline in production, due to the advanced age, was quite noticeable.

With those animals that were yearlings or calves or in-dam when they arrived, a somewhat unusual behavior is noted in table IV. There were seven animals in this group. Of the four that came as yearlings, none of them freshened until 3 years old. Then at this age all four heifers made exceedingly creditable records and, as is so often true of heifers that make very good earlier records, they did not continue at such a rate for the next year or two. Those cows that started in the trial as calves showed more regular production increases in successive years but their regularity is obscured in the table by the unusual responses of those animals that were secured as yearlings.

Even tho these younger animals failed to show decided increases in production during later years over their first year's records, their average lifetime records are considerably higher than those of the cows that were mature upon arrival. This situation is revealed in table V.

For all lactations completed those cows of mature age when they arrived made an average production of 3,169 pounds of milk and 154 pounds of fat. Those cows designated as four-year-olds produced 14 percent more milk and 8 percent more fat. They received the benefits of improved feeding which was begun at an earlier period of their lives. While the differ-

TABLE V. YEARLY PRODUCTION OF ALL SCRUB COWS IN EACH GROUP.

Group as based on age at arrival	No. of cows	No. of lactations	Average production		Increase in production over group designated as mature	
			Milk pounds	Fat pounds	Milk percent	Fat percent
Mature	5	15	3169	154		
Four-year-olds	2	15	3598	166	14	8
Heifers	7	28	4036	191	27	24

ences in production between these two groups are not great they signify that the earlier favorable environment had an effect in inducing higher production thruout all the lactations.

The decided advantages of providing young dairy females with adequate care and feed are emphasized in the greater records that were secured with those cows that reached the station when they were yearlings or younger. With these the increases were 27 percent in milk and 24 percent in fat over the records made by the cows in the mature group. This is quite substantial evidence that the cows that have been properly handled when young will produce more abundantly in later periods than will those that are neglected before they attain milking age.

An important fact to note in connection with table V is the creditable yields secured from these scrub cows. The cows were purchased because of their inferiority as dairy animals, yet when properly fed their average production was from 154 to 191 pounds of butterfat. This production compares favorably with the average yearly butterfat yields now secured from the cows of Iowa. Iowa cows are undoubtedly superior to these scrubs in their inherent ability to produce milk and butterfat, yet because of negligence in their feeding they are not permited to assert their superiority.

THE USE OF A SCRUB SIRE

As has been suggested, in the original purchase there were two calves secured along with their mothers. These were nos. 58 and 59, out of cows 8 and 7, respectively. No. 60 out of 31 was dropped after arrival. All three of these calves were sired by a scrub bull. Table VI shows the production of these animals in comparison with that of their dams.

On comparing the scrub daughters' records with those of their dams it is found that they vary quite irregularly. On

TABLE VI. PRODUCTION OF TWO GENERATIONS OF SCRUBS.

Dams				Daughters					
Cow No.	No. of lactations	Average production		Cow No.	No. of lactations	Average production		Increase in production	
		Milk pounds	Fat pounds			Milk pounds	Fat pounds	Milk percent	Fat percent
7	3	2366	138	59	1	3747	180	58	30
8	3	2339	124	58	3	3034	153	30	23
31	7	3463	168	60	6	3313	178	—4	6
Average	13	2951	151		10	3273	171	11	13

the average the daughters produced only 11 percent more milk and 13 percent more fat than did their dams. It has just been shown that improved feed and care will bring about greater improvement than this. Recognizing that the heifers were grown out under more favorable surroundings, it may be deduced that the scrub sire was valueless, and that the increase in the production of his daughters over their dams was in reality due to the better care they received early in life.

THE INFLUENCE OF PUREBRED SIRES

In this work the influence of the purebred dairy sires upon the production of their grade daughters is presented in four separate phases. The first one relates to the use of the bulls of the three breeds upon the scrub cows and compares the first generation grades with their dams. The second one compares second generation grades of the three breeds with their dams of the first generation and with their scrub granddams. The third phase to be presented deals with Holstein grades of the third generation while the fourth phase carries the comparisons on to the fourth generation of Holstein grades.

The results of this work cannot be taken as breed comparisons because obviously all bulls were not bred to the same cows

TABLE VII. PRODUCTION OF ONE GENERATION OF GRADES.

Cows in line of descent (One indentation for each generation) Cow number	Number of lactations	Average production		Increase over scrubs	
		Milk pounds	Fat pounds	Milk percent	Fat percent
Guernseys					
6	8	3715	165		
110	3	3821	163	3	—1
31	7	3463	168		
288	2	5401	309	56	84
33	3	4338	183		
87	4	4213	180	—3	—2
52	7	3742	169		
308	2	5356	281	43	66
53	7	5259	234		
180	3	3639	181	—31	—23
253	4	6168	306	17	31
58	3	3034	153		
175	3	6286	323	107	111
Average of each generation					
Scrubs (6)	35	4188	189		
First (7)	21	4966	244	19	29

TABLE VII—Continued

Holsteins					
8	3	2339	124		
68	3	5180	210	121	69
52	7	3742	169		
69	5	6700	282	79	67
56	3	3875	193		
77	6	6955	266	79	38
60	6	3313	178		
207	4	6092	288	84	62
Average of each generation					
Scrubs (4)	19	3406	169		
First (4)	18	6397	266	88	57
Jerseys					
31	7	3463	168		
174	3	5009	264	45	57
53	7	5259	234		
213	4	4458	236	—15	1
60	6	3313	178		
241	2	6138	349	85	96
Average of each generation					
Scrubs (3)	20	4047	194		
First (3)	9	5015	270	24	39
All Grades					
Average of each generation					
Scrubs (9)	47	3970	186		
First (14)	48	5512	257	39	38

and, consequently, were not given equal opportunities. Neither is it possible to assume that the bulls used here were equally representative of the respective breeds.

One Generation of Grades

In the comparison involving first generation grades, shown in table VII, there are included the records of all scrubs that had daughters which made records. Only nine of the cows had such daughters. Also the records on all such daughters are included. In such a case as with cow no. 53 which had two grade Guernsey daughters, the record of the cow is used as many times in calculating the average production of the scrubs as she has daughters. This procedure is for the purpose of securing reliability in these averages. If a cow's influence on

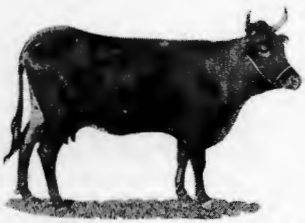

Fig. 3. Scrub No. 33. Average production—183 pounds of fat.

Fig. 4. First generation Guernsey grade No. 87, out of No. 33 and by sire A. Average production—180 pounds of fat. Decrease under scrub—2 percent.

Fig. 5. Second generation Guernsey grade No. 296, out of No. 87 and by sire B. Average production—435 pounds of fat. Increase over scrub—138 percent.

the average production of the grades is multiplied thru the appearance of more than one daughter's records in this average, it is proper that her influence upon the average for the scrubs should be similarly multiplied. Also the averages are weighted according to the number of lactations each cow has.

In table VII considerable variation is observed in the production of the first generation grades. Cow no. 180 produced 23 percent less fat than did her dam. This is the poorest showing of any grade of the three breeds. On the other hand, the first generation Guernsey no. 175 showed the greatest improvement of any of the cows of that generation. Her production exceeded her dam's by 111 percent in fat. It is to be noted that the dam of no. 180 was the highest producer of all the scrubs, while the dam of no. 175 had the second lowest record of all the scrubs. This great variation among the dams of the Guernsey grades had some influence in inducing the variation in productivity among the grades themselves, especially when this productivity is measured by percentage increases. Naturally, a greater percentage increased production

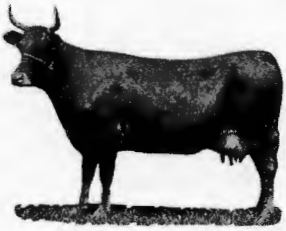

Fig. 6. Scrub No. 58. Average production—153 pounds of fat.

Fig. 7. First generation Guernsey grade No. 175, out of No. 58 and by sire B. Average production—323 pounds of fat. Increase over scrub—111 percent.

Fig. 8. Second generation Guernsey grade No. 343, out of No. 175 and by sire D. Average production—436 pounds of fat. Increase over scrub—185 percent.

in a daughter over her dam is expected when the dam is a relatively low producer. Conversely, lower percentage increases are expected when the dam has a particularly creditable record. These facts are established in the material in table XI appearing later.

Nevertheless, while this situation tends to explain partly the variation in the increases secured with the Guernsey grades, the fact remains that such a cow as no. 180 could not be a credit to a dairy herd regardless of the productive ability of her dam. The sire of no. 180 failed in this instance in effecting the improvement demanded of a purebred bull.

The Guernsey grades nos. 87 and 110 also showed slight decreases in production under their dams. On the average all the first generation Guernsey grades produced 19 percent more milk and 29 percent more fat than did their dams.

All of the Holstein first generation grades showed increases in production over their dams. The average increases for them were 88 percent in milk and 57 percent in fat. Again the greatest individual increase was secured with a cow the dam

of which had a very low record. This cow was no. 68. Her dam, no. 8, had the lowest record of any of the scrubs.

There were only three first generation grades in the Jersey line. Two of these showed excellent increases. The third, no. 213, produced only 1 percent more fat than the dam. But the dam was no. 53, the highest producer of all the scrubs. She is also the dam of the Guernsey grade no. 180, which grade has just been discussed because of her decided inability as a producer.

The average increases for all the first generation Jersey grades were 24 percent in milk and 39 percent in fat.

The last part of table VII gives the average increases that were obtained for all the first generation grades when they were grouped together without regard to breeds. The average production of all the scrubs, weighted according to the number of lactations for each cow and repeating each cow as many times as she had daughters, was 3,970 pounds of milk and 186 pounds of fat. The daughters produced 5,512 pounds of milk or 39 percent more and 257 pounds of fat or 38 percent more.

TABLE VIII. PRODUCTION OF TWO GENERATIONS OF GRADES.

Cows in line of descent (One indentation for each generation) Cow No.	No. of lactations	Average production		Increase over scrubs		Increase over previous generation	
		Milk pounds	Fat pounds	Milk percent	Fat percent	Milk percent	Fat percent
Guernseys							
31	7	3,463	168				
288	2	5,401	309	56	84	56	84
391	5	6,890	346	99	106	28	12
33	3	4,338	183				
87	4	4,213	180	—3	—2	—3	—2
236	2	6,346	320	46	75	51	78
296	3	9,107	435	110	138	116	142
52	7	3,742	169				
308	2	5,356	281	43	66	43	66
460	1	6,304	332	68	96	18	18
53	7	5,259	234				
180	3	3,639	181	—31	—23	—31	—23
301	1	8,270	427	57	82	127	136
356	3	6,367	349	21	49	75	93
53	7	5,259	234				
253	4	6,168	306	17	31	17	31
448	1	6,973	370	33	58	13	21
496	2	8,845	358	68	53	43	17
58	3	3,034	153				
175	3	6,286	323	107	111	107	111
298	4	5,810	294	91	92	—8	—9
343	1	8,522	436	181	185	36	35
Average of each generation							
Scrubs (5)	27	4,480	202				
First (6)	18	5,129	253	14	25	14	25
Second (10)	23	7,155	355	60	76	40	40

TABLE VIII—Continued

Holsteins							
52	7	3,742	169				
69	5	6,700	282	79	67	79	67
281	2	9,409	347	151	105	40	23
323	2	6,190	248	65	47	—8	—12
373	2	7,786	303	108	79	16	7
56	3	3,875	193				
77	6	6,955	266	79	38	79	38
233	4	12,818	486	231	152	84	83
282	1	10,629	402	174	108	53	51
60	6	3,313	178				
207	4	6,092	288	84	62	84	62
311	3	11,819	491	257	176	94	70
463	4	9,950	364	200	104	63	26
Average of each generation							
Scrubs (3)	16	3,631	176				
First (3)	15	6,649	278	83	58	83	58
Second (7)	18	10,218	393	181	123	54	41
Jerseys							
31	7	3,463	168				
174	3	5,009	264	45	57	45	57
245	1	5,411	287	56	71	8	9
53	7	5,259	234				
213	4	4,458	236	—15	1	—15	1
398	6	6,612	347	26	48	48	47
60	6	3,313	178				
241	2	6,138	349	85	96	85	96
348	5	6,677	319	102	79	9	—9
Average of each generation							
Scrubs (3)	20	4,047	194				
First (3)	9	5,015	270	24	39	24	39
Second (3)	12	6,539	331	62	71	30	23
All Grades							
Average of each generation							
Scrubs (7)	36	4,110	192				
First (12)	42	5,815	267	41	39	41	39
Second (20)	53	8,056	363	96	89	39	36

Two Generations of Grades

Table VIII gives the data for the scrub cows and two generations of grades. Included in this table are only those scrubs that had daughters which in turn had daughters of the second generation. Only seven of the scrubs qualify in this respect. Two of the scrubs, nos. 6 and 8, which appeared in the previous table as dams of first generation grades, drop out because their daughters failed to produce any daughters.

In table VIII there appear 12 grades of the first generation and they had 20 second generation grade daughters. As in

table VII, each dam and granddam are repeated as many times as they have second generation offspring.

The second generation grades showed a uniformly high production, which was in all cases greater than that of the scrub granddams. In a few cases the production of second generation grades was less than that of their dams.

The second generation Guernsey grades produced an average of 60 percent more milk and 76 percent more fat than their scrub granddams. There is noticeably less variation in the records of these grades of the second generation than those of the first. The greatest individual increase with the second generation grades of any of the breeds is with the Guernsey grade no. 343. She showed an increase in fat of 185 percent over the scrub granddam. Her dam, no. 175, it will be recalled, showed the greatest increase of any of the first generation grades but, in spite of this liberal record of the dam, 343 made 35 percent more fat than she did.

The second highest increase of any of the second generation Guernsey grades over the scrubs is with no. 296. She produced 138 percent more fat than her granddam while her dam produced 2 percent less.

The lowest percentage increase secured with any of the second generation Guernsey grades was with no. 356. Her fat record was only 49 percent greater than that of her scrub granddam, but her dam was no. 180, which produced 23 percent less than the scrub; therefore, no. 356's increase was 93 percent over her dam.

It is interesting to note that the first generation Guernsey grades produced an average of only 25 percent or 51 pounds of fat more than their scrub dams. However, the grades of the second generation produced 40 percent or 102 pounds of fat more than their dams. Other things being equal, the improvement in the second generation over the first would be expected to be less, both in percentage and in pounds, than the improvement in the first generation over the scrubs. This is because of the higher records of the dams and the naturally greater difficulty that is anticipated in effecting improvement over the better cows.

In this work the relatively greater increases that were secured with the second generation grades suggest that the sires involved in this generation were superior to those in the first. This is undoubtedly true. Detailed consideration will be given the sires later.

The second generation Holstein grades produced an average of 123 percent more fat than the scrub granddams. As would be expected the increase in milk production was even greater than this, it being 181 percent. The greatest individual

increase in fat yield was with no. 311. She made 176 percent more than the scrub. The Holstein grade no. 323 showed the lowest increase over the scrub of any of the second generation grades. Her record was only 47 percent greater than that of her scrub granddam. This is even 12 percent less than the record of the dam.

It is recalled that with the Guernseys the second generation showed greater improvement over their dams than did the first over their dams both when measured as percentage increases and when measured in pounds. However, with the Holstein grades the increase of the first generation over the scrubs was 58 percent while the increase of the second generation over the first was only 41 percent. Nevertheless, when measured quantitatively the increase was only 102 pounds in the first generation and it was 115 pounds in the second. Again it appears that relatively better bulls were used in securing second generation grades of this breed.

The second generation of Jersey grades showed average increases over the scrubs of 62 percent in milk and 71 percent in fat production. This was 30 percent more milk and 23 percent more fat than the first generation grades produced. The increases over the scrubs varied from 48 percent with no. 398 to 79 percent with no. 348. On a quantitative basis the first generation Jerseys produced 76 pounds more fat than did the scrubs, while the second generation grades produced 61 pounds more fat than the first.

When the records for the grades of all breeds are combined, those of the second generation show average increases over the scrub granddams of 96 percent in milk and 89 percent in fat. In other words, the use of purebred dairy sires for two generations nearly doubled the production that was secured from the scrub cows.

All the first generation grades yielded an average of 39 percent or 75 pounds of fat more than the scrubs while the second generation grades showed an increase over the first of 36 percent or 96 pounds.

Considering the increases in the first generation alone, there is ample evidence of the effectiveness of purebred sires in improving the productivity of common cows, but when the even greater improvement in the second generation is recognized there is established a very forceful tribute to the value of such sires.

Three Generations of Holstein Grades

As has been explained, the matings were carried beyond the second generation only in the case of the Holsteins. Records have been secured on four of the third generation Holstein

Fig. 9. Scrub No. 53. Average production — 234 pounds of fat.

Fig. 10. First generation Jersey grade No. 213, out of No. 53 and by sire K. Average production — 236 pounds of fat. Increase over scrub—1 percent.

Fig. 11. Second generation Jersey grade No. 398, out of No. 213 and by sire N. Average production— 347 pounds of fat. Increase over scrub——48 percent.

grades. Two of these grades trace back to the same granddam, no. 69, so she and her scrub dam are repeated in the averages in table IX. The table shows the records of the four grades in the third generation together with the records of only those cows that occur in the lines of ancestry of these four grades.

From the table it is noted that the average production of the third generation Holstein grades was 139 percent greater than that of the scrubs. The first generation produced 59 percent more than the scrubs, the second generation 42 percent more than the first but this third generation produced an average increase over the second of only 6 percent or 22 pounds.

A study of the individual third generation grades reveals that two of them, nos. 485 and 504, yielded considerably more than their dams—27 percent and 33 percent, respectively. On the other hand, two of the grades produced slightly less than their dams. The small average increase in this third generation over the second suggests that a point has been reached

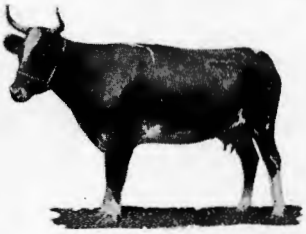

Fig. 12. Scrub No. 60. Average production—178 pounds of fat.

Fig. 13. First generation Jersey grade No. 241, out of No. 60 and by sire K. Average production—349 pounds of fat. Increase over scrub—96 percent.

Fig. 14. Second generation Jersey grade No. 348, out of No. 241 and by sire M. Average production—319 pounds of fat. Increase over scrub—79 percent.

beyond which further improvement would not be regularly anticipated from the use of sires of only the caliber of those used in this work.

Four Generations of Holstein Grades

There have been only three grades of the fourth generation to complete records and this number is fewer than would be desired. Yet the uniform behavior of the three cows supports the conjecture just offered that a point in production had been reached with the third generation Holstein grades beyond which further improvement would not be regularly anticipated. The fourth generation showed no increases over the third. There were decreases in all cases amounting to 24 percent with no. 587, 11 percent with no. 634 and 6 percent with no. 578.

The fourth generation grades produced an average of 364 pounds of fat; this was 110 percent more than was produced by the scrubs but was 15 percent less than their own dams. It must be recognized that these dams were very creditable producers having an average record of 13,308 pounds of milk

TABLE IX. PRODUCTION OF THREE GENERATIONS OF HOLSTEIN GRADES.

Cows in line of descent (One indentation for each generation) Cow No.	No. of lactations	Average production		Increase over scrubs		Increase over previous generation	
		Milk pounds	Fat pounds	Milk percent	Fat percent	Milk percent	Fat percent
52	7	3,742	169				
69	5	6,700	282	79	67	79	67
281	2	9,409	347	151	105	40	23
485	4	14,029	439	275	160	49	27
52	7	3,742	169				
69	5	6,700	282	79	67	79	67
373	2	7,786	303	108	79	16	7
504	1	12,992	402	247	138	67	33
56	3	3,875	193				
77	6	6,955	266	79	38	79	38
282	1	10,629	402	174	108	53	51
399	3	11,384	390	194	102	7	—3
60	6	3,313	178				
207	4	6,092	288	84	62	84	62
311	3	11,819	491	257	176	94	70
577	1	11,357	439	243	147	—4	—11
Average of each generation							
Scrubs (3)	16	3,648	175				
First (3)	15	6,698	279	84	59	84	59
Second (4)	8	10,059	397	176	127	50	42
Third (4)	9	12,735	419	249	139	27	6

and 426 pounds of fat. It may appear that such an average record is not very high but it is repeated that it represents all the lactation periods of all the cows and is not an isolated record from each cow.

THE SIZE OF THE DAM'S RECORD AS A FACTOR IN THE PERCENTAGE INCREASE BY THE DAUGHTER

It is recognized that when the dam's record is relatively low a percentage increase in production for the daughter is easily possible. Even a sire of only mediocre transmitting ability is likely to effect consistent increases in his daughters out of such dams. On the other hand, as the dams' records become more creditable, the increases in the daughters' records are not so likely unless exceptional bulls are used.

McDowell and Parker (8) have commented on this situation. In their study of the records of 1,016 grade cows in cow testing associations in the United States, they found the tendency for the daughters' records to excel those of the dams as long as the dams produced less than 349 pounds of butterfat. When the dams' records exceeded this figure, the daughters tended to show decreases in production.

In the work reported here an analogous situation has been noted. In table XI the dams have been grouped according to

TABLE X. PRODUCTION OF FOUR GENERATIONS OF HOLSTEIN GRADES.

Cows in line of descent (One indentation for each generation) Cow No.	No of lactations	Average production		Increase over scrubs		Increase over previous generation	
		Milk pounds	Fat pounds	Milk percent	Fat percent	Milk percent	Fat percent
52	7	3,742	169				
69	5	6,700	282	79	67	79	67
281	2	9,409	347	151	105	40	23
485	4	14,029	439	275	160	49	27
587	1	11,296	334	202	98	—19	—24
634	1	11,711	389	213	130	—17	—11
56	3	3,875	193				
77	6	6,955	266	79	38	79	38
282	1	10,629	402	174	108	53	51
399	3	11,384	390	194	102	7	—3
578	2	10,926	366	182	90	—4	—6
Average of each generation							
Scrubs (2)	10	3,766	173				
First (2)	11	6,796	276	80	60	80	60
Second (2)	3	9,653	358	156	107	42	30
Third (2)	7	13,308	426	253	146	38	19
Fourth (3)	4	11,215	364	198	110	—16	—15

the size of their records. The average production increases of the daughters of dams in the different groups are shown in the table.

The lowest producing group of dams in table XI produced 124 pounds of butterfat. The daughter shows a production increase of 69 percent. This lowest group consisted of only one scrub cow. The next group consisted also of scrubs. The daughters of the dams in this group produced 64 percent more fat than did the dams. The daughters from the third group appear somewhat irregular in their behavior and their increase amounted to 80 percent. The daughters from the next three groups show lower percentage increases with the higher

TABLE XI. INFLUENCE OF DAM'S RECORD UPON THE PERCENTAGE INCREASE IN PRODUCTION BY THE DAUGHTER.

Fat production range of dams pounds	No. of dams	Average fat yield		Percentage increase of daughters' yields over dams'
		Dams pounds	Daughters pounds	
76-125	1	124	210	69
126-175	6	165	270	64
176-225	8	182	327	80
226-275	7	248	321	29
276-325	12	298	358	20
326-375	2	348	379	9
376-425	2	396	378	—5
426-475	2	439	362	—18
476-525	1	491	439	—11

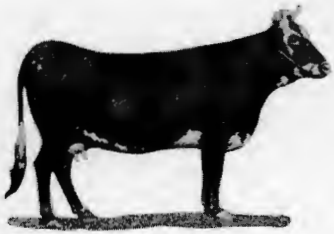

Fig. 15. Scrub No. 52. Average production—169 pounds of fat.

Fig. 16. First generation Holstein grade No. 69, out of No. 52 and by sire F. 'Average production—282 pounds of fat. Increase over scrub—67 percent.

Fig. 17. Second generation Holstein grade No. 281, out of No. 69 and by sire H. Average production—347 pounds of fat. Increase over scrub—105 percent.

Fig. 18. Third generation Holstein grade No. 485, out of No. 281 and by sire I. Average production—439 pounds of fat. Increase over scrub—160 percent.

Fig. 19. Fourth generation Holstein grade No. 634, out of No. 485 and by sire J. Average production—389 pounds of fat. Increase over scrub 130 percent.

Fig. 20. Scrub No. 56. Average production—193 pounds of fat.

Fig. 21. First generation Holstein grade No. 77, out of No. 56, and by sire F. Average production—266 pounds of fat. Increase over scrub—38 percent.

Fig. 22. Second generation Holstein grade No. 282, out of No. 77 and by sire H. Average production—402 pounds of fat. Increase over scrub—108 percent.

Fig. 23. Third generation Holstein grade No. 399, out of No. 282 and by sire I. Average production—390 pounds of fat. Increase over scrub—102 percent.

Fig. 24. Fourth generation Holstein grade No. 578, out of No. 399 and by sire J. Average production—366 pounds of fat. Increase over scrub—90 percent.

producing dams. With those dams that averaged 348 pounds of fat the daughters produced only 9 percent more. McDowell and Parker say that 349 pounds of fat marks a point in the dams' production beyond which the daughters do not show increases. Apparently in the work here as revealed in table XI, such a point lies somewhere between a production of 348 pounds and 396 pounds of butterfat.

It appears that this point is near 375 pounds. When the dams produced less than this amount there was a tendency for the daughters to exceed their records; when the dams exceeded this point in production the daughters tended to show decreases.

PERSISTENCY OF PRODUCTION

As used here, persistency means the ability of the cows to sustain a relatively high milk yield during each month of a lactation period. In general those cows which have long, well sustained milking periods are the most desirable.

Figure 25 shows the average fat production of the cows by months, or 30-day periods. In these data on persistency the records are not computed to a mature basis. Included in the averages are 14 scrub cows for 58 lactation periods, 14 first

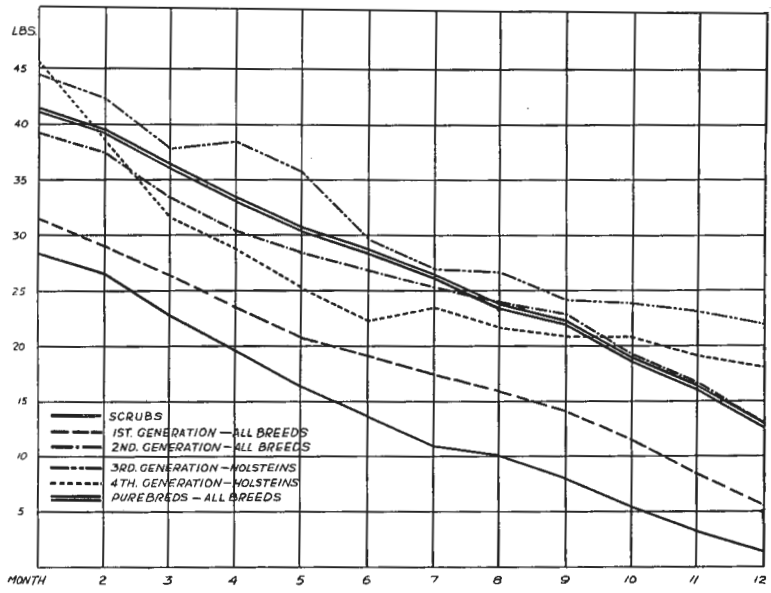

Fig. 25. Monthly Fat Production of Scrubs, Grades and Purebreds.

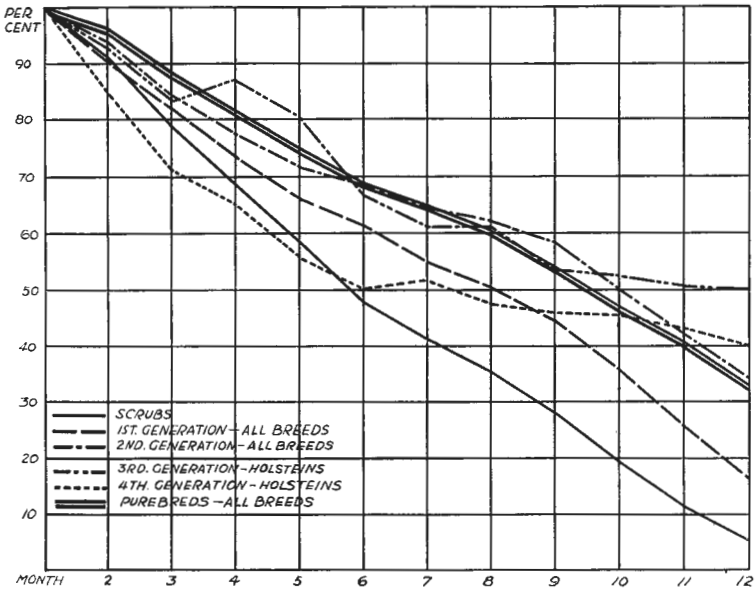

Fig. 26. Relative Monthly Fat Production of Scrubs, Grades and Purebreds.

generation grades of all three breeds for 48 lactations, 20 second generation grades of all three breeds for 53 lactations, 4 third generation Holstein grades for 9 lactations and 3 fourth generation Holstein grades for 4 lactations. To afford a comparison, there is also shown the average production as found by McCandlish (6) of 116 purebreds for 300 lactations. These were the purebred Ayrshires, Guernseys, Holsteins and Jerseys in the station herd.

While fig. 25 shows the absolute quantity of fat produced by the cows in successive months of the lactations, fig. 26 reveals the relative persistency of these cows when expressed as a percentage of the first month's production. In fig. 26 the production of the cows during the first month of lactation is indicated as 100 percent. It is to be noted in fig. 26 that the position of the lines does not represent the quantity of monthly nor yearly production; it merely represents persistency as described above.

From fig. 25 it is seen that the production of the scrubs was low early in the lactation and it continued low thruout the year. Figure 26 shows that they produced only 5 percent as much fat in the twelfth month as in the first. Their yearly production was only 169 pounds of butterfat. The first generation grades produced more during each month than did the scrubs.

In the twelfth month their production was 16 percent of their first month's production and their yield of fat was 224 pounds for the year.

The second generation grades manifest further improvement. As shown in fig. 25, after the eighth month the second generation grades even excelled the purebreds in productivity. They exceeded the purebreds in persistency after the seventh month.

The third generation Holstein grades showed the greatest production of any of the groups. They exceeded the purebreds thruout the year. Their yearly record was 376 pounds of butterfat. Figure 26 shows that these third generation Holstein grades behaved very irregularly as regards persistency, at first falling down lower than the purebreds, then recovering at the fourth month, again falling at the sixth month and finally finishing with a remarkable display of persistency in the last three months. In their twelfth month they produced 50 percent as much as in the first month.

The fourth generation Holstein grades produced more than any other group during the first month. But thereafter they fell rapidly and fig. 26 indicates that their relative persistency was lower than even the scrubs until the sixth month. In this month they were producing only 50 percent as much as in the first month. From then on they effected remarkable recovery and dropped only 10 percent during the last six months. Their average yearly record was 317 pounds of fat.

THE INFLUENCE OF INDIVIDUALITY

It is commonly recognized that cows vary materially in productive ability. Generally such variations may be explained as due to differences in ancestry and environment. However, it is also well known that great differences in production may exist among cows of very similar breeding, or even among those from common parents—i. e. full sisters.

The data of this experiment furnish some notable examples of this individual variation. The Holstein sire H, Spring Farm King Pontiac 8th, sired three daughters out of the first generation grade no. 69. Number 69 had an average production of 282 pounds of butterfat. One of the daughters, no. 323, produced 12 percent less, another 7 percent more and still another 23 percent more than the dam. These three full sisters were fed and managed under as nearly identical conditions as could be provided.

An even greater contrast in production between full sisters is afforded in the records of two daughters by the Guernsey sire B, Imp. Rouge II's Son, and out of scrub cow no. 53. This is shown in table XII.

TABLE XII. VARIATION IN THE PRODUCTION OF FULL SISTERS.

Cow	No. of lactations	Average production		Increase over scrubs	
		Milk pounds	Fat pounds	Milk percent	Fat percent
Scrub, No. 53	7	5259	234		
First generation Guernsey No. 180	3	3639	181	—31	—23
First generation Guernsey No. 253	4	6168	306	17	31

The grade no. 180 has been mentioned previously as showing a great decrease in production under her dam. Also attention has been called to the fact that her dam, no. 53, was the highest producer among the scrubs. Number 180 produced 23 percent less fat than her dam, while the full sister, no. 253, produced 31 percent more. The one daughter produced 125 pounds or 69 percent more fat than did the other one.

Individuality is a considerable factor in production and can not be ignored. Within a good family of cows, some inferior

Fig. 27. Scrub No. 53, dam of first generation Guernsey grades Nos. 180 and 253. Average production—234 pounds of fat.

Fig. 28. First generation Guernsey grade No. 180, full sister to No. 253, out of No. 53 and by sire B, Imp. Rouge II's Son. Average production—181 pounds of fat. Decrease under dam—23 percent.

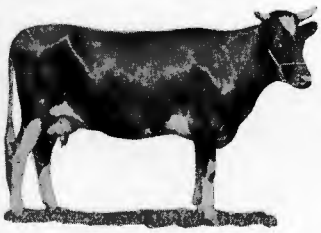

Fig. 29. First generation Guernsey grade No. 253, a full sister to No. 180. Average production—306 pounds of fat. Increase over dam—31 percent. Increase over full sister—69 percent.

animals may occur. Records of production only will reveal such animals and they must be weeded out if the herd is to yield the fullest profits.

THE IMPROVEMENT IN TYPE

The scrub cows were decidedly inferior in type; the grades showed quite regular improvement in this regard. In general, the grades of the first generation carried the characteristics of the breed of their sires so that they could be identified as carrying the blood of these breeds. Of course the breed characteristics were intensified in the later generations. Some of the cows of these later generations showed such breed characteristics that they could not be distinguished from purebreds.

Probably the most apparent, and certainly the most significant, improvement was the larger and more symmetrical udders. Then the grades showed greater capacity and more thrift. Generally, the top-lines were straighter and they showed superior dairy character over the scrubs.

COSTS AND RETURNS

While the chief object of this investigation was to measure the influence of purebred dairy sires in establishing a herd of abundant producing cows, it has been recognized at all times that abundant production, within itself, should not be the sole aim of a dairyman. All dairymen should demand economical production. However, it has been established from many sources that abundant production from each cow is the only dependable manner of attaining economical production. The results secured in this work clearly demonstrate the superiority of the grades over the scrubs in their ability to use feed efficiently and to produce milk at a lower cost. The daily feed records on all the cows used in this experiment for their entire lives together with a record of all the milk produced by these cows afford data of considerable interest and value.

In making the cost studies, difficulty is encountered in ascribing equitable prices to the feeds that were used. Certain feeds were used only during early years of the experiment while other feeds have been used only more recently. Each feed has been included in table XIII at a figure that was largely determined by the price of the feed at the time it was used.

In table XIV the cost data for the scrubs and two generations of grades of all breeds are grouped into lactation periods and lactation and dry periods. A lactation period is for 360 days or for less if the cow went dry earlier than this. The feed consumed during the period is charged against the milk

TABLE XIII. PRICES OF FEEDS.

Feed	Price per ton
Cracked corn, corn and cob meal	$ 20.00
Ground oats	25.00
Bran, ground barley, dried beet pulp	30.00
Hominy feed, cottonseed cake	35.00
Cottonseed meal, copra meal, gluten feed, brewers' and distillers' dried grains, molasses	40.00
Germ oil meal	45.00
Linseed meal, peanut meal, soybean meal	50.00
Cracked soybeans	60.00
Hay, all kinds	20.00
Silage	6.00
Corn fodder	12.00
Corn stover	4.00
Roots	7.00
Soiling crops	5.00
Pasture, per day	0.08

yield for the period. A lactation and dry period covers the time from one freshening to the next. It may involve less than 360 days in milk or it may involve more. The succeeding dry period is included regardless also of its length. Thus the feed for the cow during the time she is milking as well as when she was dry is charged to the milk yield for that entire milking period. Obviously the feed costs that are presented in the data for lactation and dry periods are greater than for lactation periods only. This method of treatment also reveals the higher costs with those cows of lower persistency and consequent longer dry periods.

Table XIV shows the amounts of different kinds of feed which the scrubs and the two generations of grades used for the production of 100 pounds of milk. There is also shown the feed cost per 100 pounds of milk and the average butterfat test of the milk from the cows in the different groups. The test is used in determining the selling price of the milk. The base price for the milk was $2.45 per 100 pounds of 3.5 percent milk with a 5-cent differential for each one-tenth of one percent of variation in test from 3.5 percent.

Both for lactation periods and lactation and dry periods it is observed that the second generation grades consumed less than did the scrubs for the production of 100 pounds of milk. Thus the feed costs were considerably lower, permitting of greater returns from the second generation grades. The superior efficiency of these grades is especially manifest from the data for lactation and dry periods. Here the long dry periods of the scrubs impose a very high feed cost against their milk yields, and the gross returns for each dollar spent for feed are $1.45. This is unprofitable. On the other hand, when a dairyman can secure gross returns of $2.01 for each dollar invested

TABLE XIV. FEED REQUIREMENTS, COSTS, AND RETURNS PER 100 POUNDS OF MILK WITH TWO GENERATIONS OF GRADES.

Generation	Feeds						Feed cost dollars	Per-centage of fat	Selling price of milk dollars	Gross returns for each dollar in feed dollars
	Grain pounds	Legume hay pounds	Non-legume dry roughage pounds	Silage pounds	biling pounds	Pasture days				
Lactation Periods										
Scrub	43	17	18	97	34	4	1.71	4.73	3.07	1.79
First	40	40	4	103	64	3	1.78	4.61	3.01	1.69
Second	39	22	2	98	16	2	1.31	4.50	2.95	2.25
Lactation and Dry Periods										
Scrub	48	25	24	131	43	5	2.11	4.73	3.07	1.45
First	42	44	5	119	74	3	1.97	4.63	3.02	1.53
Second	40	28	17	120	16	3	1.48	4.55	2.98	2.01

TABLE XV. FEED REQUIREMENTS, COSTS, AND RETURNS PER 100 POUNDS OF MILK WITH FOUR GENERATIONS OF HOLSTEIN GRADES.

Generation	Feeds						Feed cost dollars	Per-centage of fat	Selling price of milk dollars	Gross returns for each dollar in feed dollars
	Grain pounds	Legume hay pounds	Non-legume dry roughage pounds	Silage pounds	Soiling pounds	Pasture days				
Lactation Periods										
Scrub	46	26	19	113	43	4	1.95	4.95	3.18	1.63
First	38	32	3	81	55	3	1.55	4.06	2.73	1.76
Second	36	19	1	90	20	2	1.20	3.85	2.63	2.19
Third	34	13	4	67	----------	1	.95	3.27	2.34	2.46
Fourth	33	18	7	87	----------	2	1.09	3.24	2.32	2.13
Lactation and Dry Periods										
Scrub	53	37	23	149	63	5	2.46	4.95	3.18	1.29
First	40	38	3	96	62	3	1.75	4.06	2.73	1.56
Second	38	22	10	107	21	2	1.34	3.88	2.64	1.97
Third	37	17	5	80	----------	2	1.11	3.30	2.35	2.12
Fourth	38	20	6	119	----------	2	1.29	3.27	2.34	1.81

in feed, as was the situation with the second generation grades, he will find his dairy operations profitable.

Table XV presents material similar to that in table XIV except that it relates only to Holstein grades and their ancestors. Here the scrubs for lactation periods have a feed cost of $1.95 for 100 pounds of milk and the gross returns for one dollar invested in feed are only $1.63. This is entirely unprofitable. The first generation of grades are somewhat more economical but assured profits are not realized until with the second generation a gross return of $2.19 is secured for each dollar spent for feed. The third generation Holstein grades, as would be expected by recalling their abundant production records, assert their superiority in economical production by returning $2.46 for each dollar invested in feed. Even when lactation and dry periods are involved the returns are $2.12.

Fig. 30. Guernsey sire B, Imp. Rouge II's Son.

Again recalling the lower production of the fourth generation Holstein grades as compared to the third generation, the reduced returns for the fourth generation are as would be expected.

A STUDY OF THE SIRES USED

Fourteen purebred sires have been used in this work. An effort was made in selecting the sires to secure bulls of desirable breeding and type, but none of them was especially outstanding in these respects. Neither were they costly. Sires of equal merit are plentiful in Iowa at very reasonable prices, prices so reasonable that the man who milks cows can not afford to do otherwise than carefully consider such bulls for his herd.

The value of the bulls used is measured chiefly by the increased production of each bull's daughters over the production of their dams. Table XVI is a summary of the influence which each of the sires exerted.

The daughters of bull A produced 1 percent less fat than their dams. This might be interpreted as a negligible influence but actually any bull which fails to improve his daughters over their dams is harmful. It is not sufficient that he merely hold their production up to their dams'. The inferiority of this bull is emphasized when it is realized that he was bred to very

mediocre scrub cows. These cows, next to those mated to bull F, were the lowest producing dams in the experiment. Two bulls, J and M, rank lower than does A in effecting improvement in their daughters, but these two bulls were bred to the two highest producing groups of dams and there is some semblance of justification for their failure.

Fig. 31. Holstein sire I, Iowana Homestead Watson.

Bull A was loaned to the Station for use in this work before the purebred Guernsey herd was established. He was of fair type but of inferior breeding so far as his parents were concerned. His dam was an untested cow. His paternal grandsire was one of the noted bulls of the breed from the standpoint of production. This emphasizes a point so often ignored by dairymen that the influence of a distant noted ancestor may be very limited and may be entirely obliterated by the damaging influence of inferior animals closer up in the pedigree.

TABLE XVI. INFLUENCE OF SIRES USED IN THE INVESTIGATIONS.

Sires	Average fat production			Rank of dams in average fat production	Rank of sires in increasing production
	Dams of daughters pounds	Daughters pounds	Increase over dams percent		
Guernseys					
A	174	172	—1	13	12
B	203	316	56	11	3
C	252	361	43	9	6
D	271	377	39	6	7
E	294	345	17	4	10
Holsteins					
F	166	262	58	14	2
G	266	486	83	7	1
H	280	358	28	5	8
I	335	399	19	3	9
J	440	382	—13	1	14
Jerseys					
K	198	293	47	12	5
L	264	287	9	8	11
M	349	319	—9	2	13
N	236	347	47	10	4

Reference to table II will furnish the numbers of the daughters of all the bulls that were used; tables VII to X show the records of these daughters.

The daughters of sire B averaged 56 percent more fat than their dams. This average gives B third rank among all the sires, a creditable performance. Yet this bull had a very peculiar effect upon the herd. He sired eight daughters. One of these was no. 180. She has been mentioned as the cow that produced 23 percent less fat than her scrub dam, the poorest showing of any of the first generation grades. On the other hand, no. 175, also a daughter of sire B, showed an increase of 111 percent, the greatest increase of any of the first generation grades. All of this bull's daughters, except no. 180 showed substantial increases over their dams. He was a valuable sire of excellent type and breeding. His dam had three advanced registry records averaging over 600 pounds of butterfat.

The situation with this sire exemplifies the necessity of practicing constant weeding out of certain inferior producers that may appear in dairy herds even tho these culls may be from excellent ancestry.

Sire F was mated to the lowest producing group of dams in the herd. His daughters showed an increase of 58 percent, ranking him second among the sires. Sire G ranked first among the bulls on the basis of the increased percentage in production of daughters over their dams. He was a son of sire F and was of excellent breeding and considerable worth.

Sire J ranked at the bottom of the list. However, the cows to which he was bred were the highest producers in the experiment and there is thus a partial explanation of his poor showing. Nevertheless, it must be recognized that this bull fell short in the service expected of him as a herd sire.

The situation with sire M is nearly the same as with J. He was mated with good cows; the daughters showed decreases in production. It appears likely that had these bulls been mated with lower producers, their daughters would have shown increases.

In general, of the bulls used, it may be said that three of them, A, J and M, proved valueless—A decidedly so; four of them, B, F, G and N, proved to be very valuable, while the other seven were of such caliber as would justify their use in reasonably good dairy herds.

Selecting a Herd Sire

The selection of a herd sire is one of the most important problems confronting a dairyman. Beginners in the dairy business seldom realize the importance of the sire in determining the success or failure with a herd. Those dairymen who have had

experience in the matter and who keep records on their cows are thoroly cognizant of the far-reaching possibilities in herd sires.

For dairy herds of average or very low producing ability, not so much care is demanded in selecting a sire as for the more improved herds. However, with no dairy herd are complete abandon and indifference in this matter justified.

From the experiences that have been encountered in selecting the sires for this experiment and from the results that have been secured, it is possible to lend emphasis upon the following five factors that must receive consideration in making selections: 1. Health, 2. Performance, 3. Breeding, 4. Type, 5. Price.

1. Health as a problem in dairy herds is receiving more and more attention each year. In the sense used here, the health of a sire refers not only to those possible pathological conditions that affect his state of nutrition but also to other possible bodily conditions, such as activity in service and his potency.

It is obvious that health is of great importance in selecting a herd sire. Great progress has been made in eliminating tuberculosis from dairy herds. Tests for this disease can be employed with great dependence and dairymen generally guarantee their salable bulls as free from infection from this organism so that buyers can secure protection in making purchases.

Infectious abortion is an acute problem in many dairy herds. The likelihood of disseminating the disease to cows thru service from an infected bull is a point in controversy among veterinary authorities. The fact remains, however, that any infected animal in a herd is dangerous. However, the dangers in this direction are not insurmountable by any means. A prospective buyer can study carefully the herd from which the sire is to be purchased. He can determine quite accurately the prevalence or absence of abortion and sterility among the cows of the herd by noting the number of calves on hand. Furthermore, he can demand the agglutination test for the *Bacterium abortus* Bang and can buy in considerable security regarding this matter.

Attention is called to the fact that all abortion disease is not due to infection from the specific organism, the *Bacterium abortus* Bang. Other organisms may be responsible in a certain percentage of abortion cases, especially when cows abort a second or third time, and the agglutination test does not reveal the presence of these other organisms. In meeting this latter situation, wherein no specific test has yet been devised, a buyer must place reliance upon the integrity of the breeder from whom the

purchase is made. In most cases of this nature such reliance is not betrayed.

Johne's disease has not received general attention among the dairymen of this country because it has not been especially prevalent. In certain herds, however, it has made serious encroachment and there are reliable predictions that before many years, Johne's disease may become extremely serious in the herds of cattle in this country.

Fortunately, recent experimentation has resulted in the discovery of a test for the disease. The test is thought to be quite reliable and it gives encouragement to the belief that a purchaser can buy in considerable security that the animal is free of infection from this organism.

Generally, in purchasing older bulls, there are greater dangers from the diseases just mentioned than are encountered in young animals. In fact it is very unusual for young animals—either males or females—to show reactions to the blood test for infectious abortion. Furthermore, at this station no cases of Johne's disease have been detected in animals younger than 2 years. On the other hand, older bulls have shown an alarming extent of infection from this disease.

Also, there are greater difficulties among older bulls in their readiness and security at service. This matter of health is therefore of paramount importance in selecting an older bull. But every buyer is entitled to demand from the seller a guarantee that the bull if properly handled will continue in active service for at least one year and preferably two. A seller should be willing to offer this guarantee or to reduce the price materially he asks for the bull.

2. Performance immediately implies the selection of proved sires, or those that have a sufficient number of milking daughters so that judgment as to the worth of the bulls may be rendered. Naturally, proved sires are of two classes—those that have demonstrated their worth thru creditable producing daughters and those that have demonstrated their unworthiness thru inferior daughters. Obviously, in selecting a proved sire only those bulls that have proved their value—not their inferiority—should be considered.

The results of this work together with the results of other experiments make it apparent that bulls vary widely in their ability to transmit high production to their daughters. This introduces an element of uncertainty into the use of purebred sires. The uncertainty must be recognized and every effort must be exerted to reduce it to a minimum. The use of proved bulls accomplishes this end and the only unqualified measure of a bull is the kind of daughters he sires. If a dairyman determines that

his next herd sire shall be a good proved one, he has established a reasonable guarantee that his herd will be improved.

In recent years there has been great interest in proved bulls, and dairymen have been widely encouraged to select such bulls. Yet a great majority of the herd sires that are selected are young ones that have not demonstrated their value. Of course, not a great many good proved bulls are available for purchase but even many such bulls do not find ready sale and are often sacrificed.

It is impossible for a bull to have proved his worth thru production records on his daughters before he is 5 years old. Dairymen hesitate to buy old bulls. Such bulls are often cross and few farms are equipped to handle ill-tempered bulls. However, the cost of building a safe bull paddock is not great. Every dairy farm should have one. Then there is the innate desire on the part of most men to own something new rather than second-hand. If a dairyman hesitates to buy a proved bull because of his preference for a "new" one, he would better sacrifice his pride in the interest of better judgment. Proved bulls are often costly, but the safest investment a dairyman can make is in a bull of proved worth.

There is often some hesitancy about buying an older bull because of the fear that he may be slow in service, sterile, or diseased. These are important considerations and they have been discussed under the section on health.

3. Breeding has particular reference to the ancestors of an animal as they would appear on a pedigree. And it is emphasized here that a pedigree is a written record of the ancestry on an animal. It is in no sense an official document and must not be confused with a certificate of registry. The latter is the official document which a breed association issues at the time an animal is registered with the association. It is the certificate of registry, not a pedigree, that establishes the purity of an animal's breeding. In the discussion here it is intended that the term, breeding, shall also embody the sisters and brothers of the bull under consideration. Of course, full sisters and brothers are of more significance in determining his value than are half sisters and brothers but the latter are more numerous. The caliber of the sisters and brothers reveals the performance of the parents. And next to the performance of a bull himself, the performance of his parents is the greatest guide in predicting his value. This is the guide upon which the greatest reliance should be placed in selecting an untried sire. If a bull has a uniformly high producing group of sisters, there is good evidence that he also has inherited the character for abundant production. However, a few high producing sisters among several inferior ones

is a situation that does not lend much confidence in the bull's own ability.

Among the individuals in a bull's ancestry, his sire and dam together are as important in determining his transmitting ability as are all other ancestors. Either one is more significant than is any individual in earlier generations. Too often a noted individual in earlier generations receives all the attention of the buyer—and this generally thru the efforts of the seller—while the inferior immediate parent is overlooked. This usually results in disappointment as was true with sire A in this experiment.

However, even recognizing the importance of the sire and dam in determining a bull's ability, one caution must be offered. A bull's dam may be of excellent type and an excellent producer but with a long line of inferior ancestors back of her. She may be merely a fortunate incident in a long row of misfortunes and as such there is little likelihood that she will transmit her desirable characters. It is a far safer plan to select a bull whose dam is an ordinarily good animal in a long line of good individuals. The same cautions apply to the male line of a bull's pedigree. The ideal pedigree carries a prolonged succession of meritorious animals.

It must be emphasized here that production records alone are not sufficient in estimating the worth of an individual in a bull's pedigree. The type of the animals is very important. This suggests the need for seeing as many as possible of a bull's ancestors before determining upon his purchase.

While blood lines are of very great importance in determining a sire's transmitting ability, it must be recognized that any family of cattle may yield some undesirable animals and that mere membership in a noted family is not alone an absolute guarantee of value.

4. Type in a dairy bull is not so valuable an index of his ability to sire creditable daughters as is type in a cow a valuable index to her producing ability. While some men even challenge the existence of any correlation between a cow's type and her producing ability, the fact remains that those cows of the proper conformation are more abundant producers than are the individuals of inferior conformation. Any assertion of such a correlation presupposes that judgment regarding an animal's typiness is not in error.

The admission that a bull's type is not an infallible guide as to his transmitting ability should not deter any dairyman from giving great consideration to type in selecting a sire.

A similar admission that even breeding can not completely indicate a bull's value can be made. Yet breeding should not be

ignored. The chief reasons why bulls of inferior conformation are used are that they are well bred or are cheap. Neither reason is sufficient to justify the use of such a bull. The only situation that can justify the use of a bull of poor type is that the bull may be a proved sire and has definitely established his ability to sire daughters of approved type and productivity.

Dairy herds in general have a great many individuals that are of inferior type and the owners of such herds are therefore laboring under a handicap. Not only are the individuals that are of inferior type, individuals of lower productive ability, their offspring are also likely to be culls. The dairyman who determines to improve the general type of his herd thru the purchase of cows, will find the cost of such a program almost prohibitive because cows of good type are not commonly available. Thus any material improvement in the type of a herd must come thru the use of a sire capable of transmitting approved type to his daughters.

5. Price is the least important consideration in buying a herd sire. Nevertheless, it is the guide that is generally relied upon in making purchases. Extravagance certainly has no place in any industry and such is true in buying bulls but if there is any venture wherein liberality is entirely commendable it is in the purchase of the herd sire. It is doubtful if any dairyman ever spends too much money for a good herd bull. The policy of false economy which is often assumed relative to the purchase of a sire can not do otherwise than lead to a poor bull. The first thought is often of price. In reality the first thought should be of the bull's merit.

If careful consideration of the important factors involved in selecting sires leads to the conclusion that a particular bull will prove entirely satisfactory, every effort should be directed toward securing him. Limited funds should not force a dairyman to accept a slightly cheaper but decidedly inferior one. Often a heifer or a cow can be sold or traded at a figure that will more than take care of the difference in price between a good and a poor bull. No female can be worth so much to a herd as can a good sire.

A common mistake in buying bulls is to wait until the last possible date before inaugurating a search for one. Then haste is demanded and critical and careful judgment are not possible. Some forethought and deliberate observations would permit of far more intelligent buying.

Excellent bulls that would prove satisfactory in most dairy herds are available in great numbers. Breeders sell bulls at very reasonable prices considering the merit in most of those that

are offered. With so many good herd sires available at reasonable prices dairymen can not afford to neglect the opportunity for careful and intelligent purchase that is offered them.

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